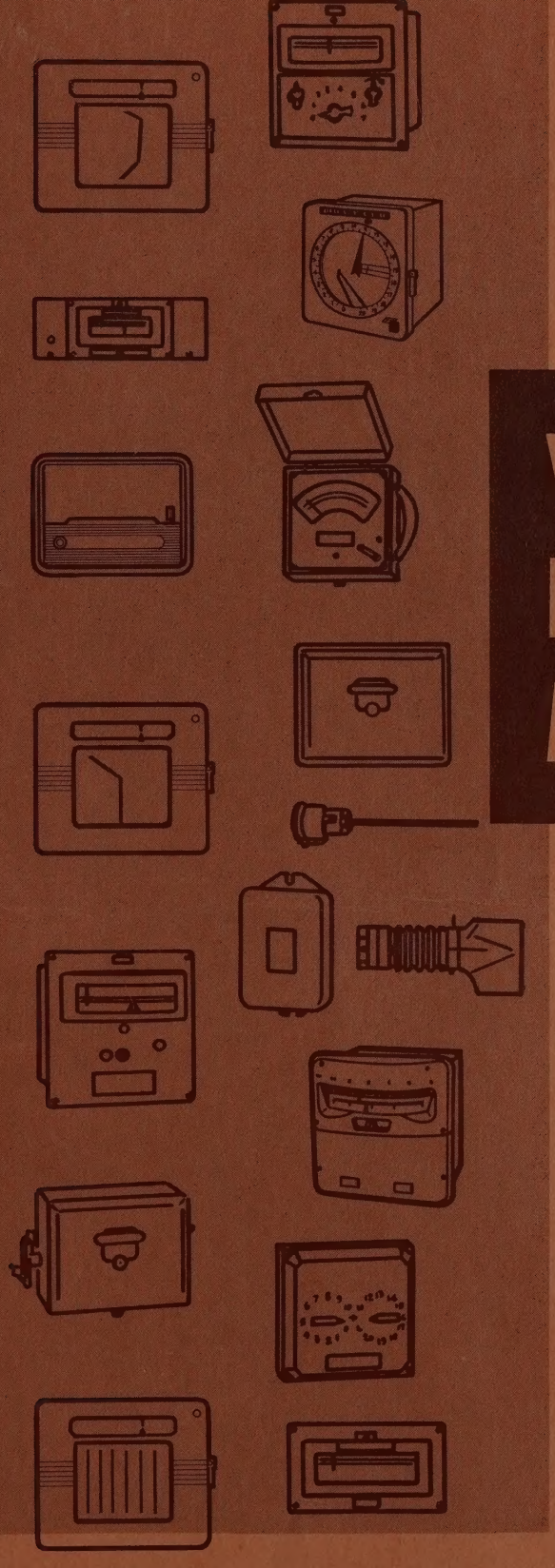
REFERENCE Volt

MODEL

350



WHEELCO INSTRUCTION MANUAL

BARBER COLMAN

BARBER-COLMAN COMPANY

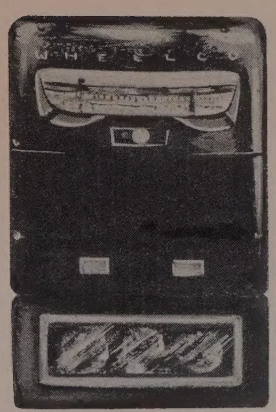
Wheelco Instruments Division | ROCKFORD, ILLINOIS, U. S. A.

INSTRUCTION MANUAL

FOR

MODEL 350

REFERENCE VOLTAGE SOURCE



The Wheelco Model 350 has been designed as a component for use in conjunction with null balancing galvanometer type indicating controller of the 400 Series.

The combination gives a measuring system that is recommended for those critical control applications requiring extreme measuring sensitivity on processes which incorporate minimum time lags compatible to 5 per cent or less proportioning band.

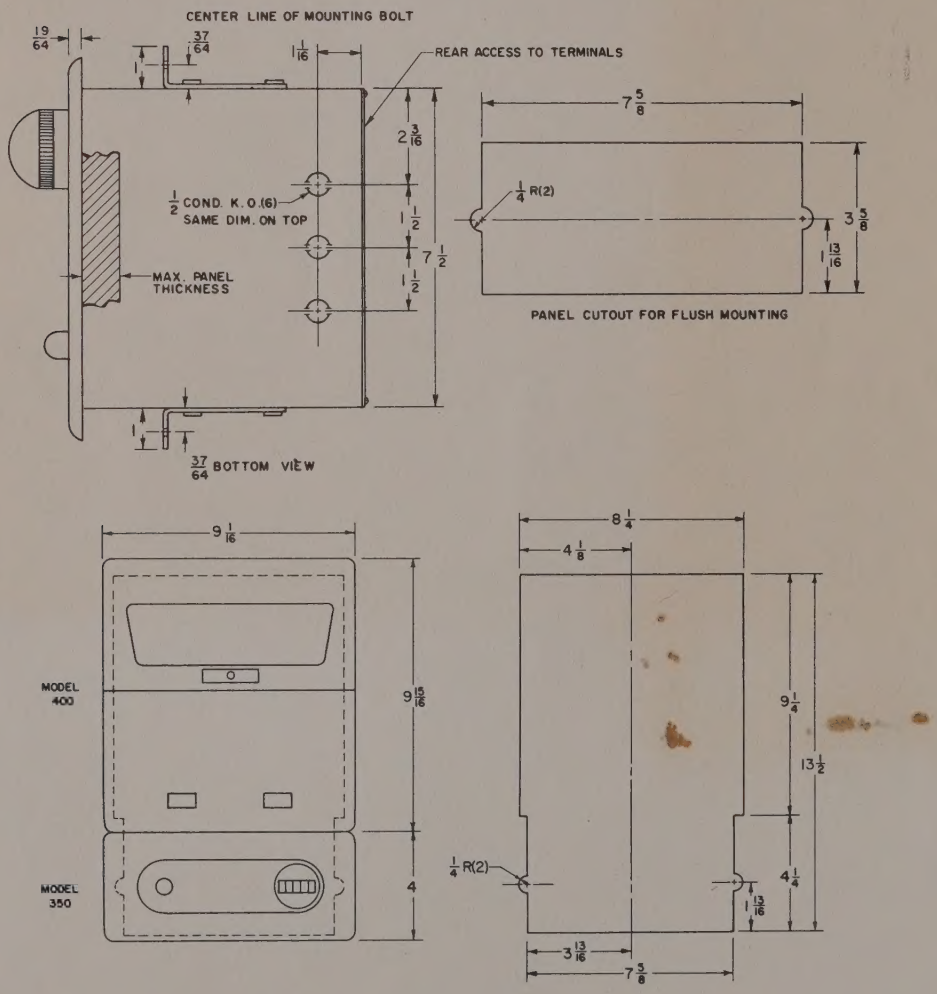
Mounting Instructions

The Model 350 reference voltage source is normally mounted below the Model 400 Series housing.

This is accomplished by following cutout dimensions below. The unit may be mounted separately using the small cutout opening dimension.

Flush mounting of the Model 350 case is accomplished by use of brackets furnished. Terminal access from rear.

CONSTANT VOLTAGE SUPPLY
PANEL ASSEMBLY



-NOTE-
FLUSH MOUNTING
CUTOUT DIMENSIONS
13-1/4" X 8-1/4"

FIG. 1

Wiring:

Instrument Power

Connect device to same 115v 60c source used for the Model 400 Controller. Available only for 115v 60c supply.

Wire to L1 and L2 Terminals on rear of Model 350 chassis.

Remove four screws and remove rear plate - chassis removable front only. Thread 14 ga. wires through grommets and connect.

Thermocouple Wiring

Using appropriate lead wire to suit thermocouple type, pass through grommet and connect proper polarity negative wire to TC - and positive wire to TC +.

Galvanometer Wiring

Thread No. 14 ga. copper wire through same grommet as T/C lead wire and connect to gal + and gal -.

Connect galvanometer + wire to TC + terminal on 400 Series left-hand terminal strip.

Connect galvanometer - wire to TC - terminal on 400 Series terminal strip. See wiring diagram Fig. 2.

In case of 407S279, refer to wiring diagram Fig. 3.

EXTERNAL WIRING DIAGRAM FOR MODEL
400 - SERIES S310 AND MODEL 350

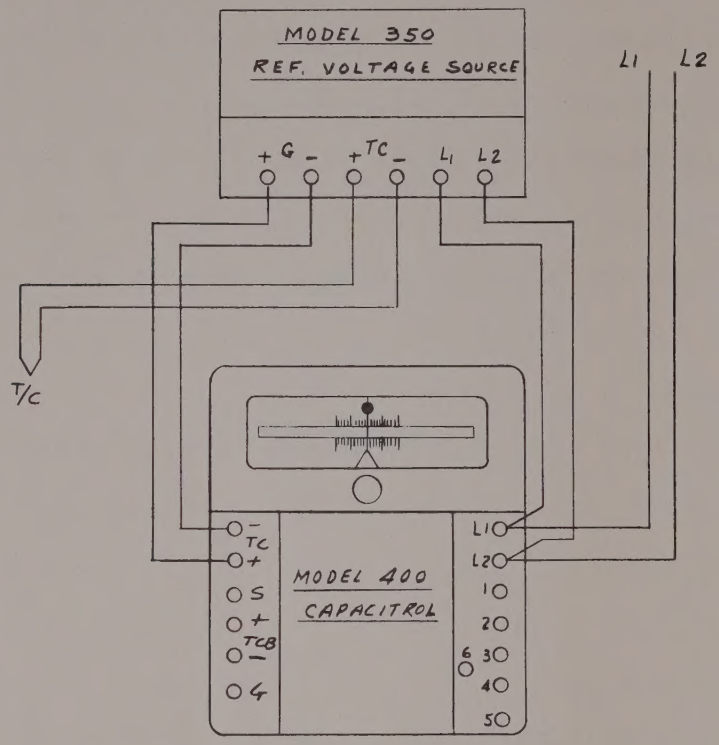


FIG. 2

EXTERNAL WIRING DIAGRAM FOR
MODEL 407 S310 S279 AND MODEL 350

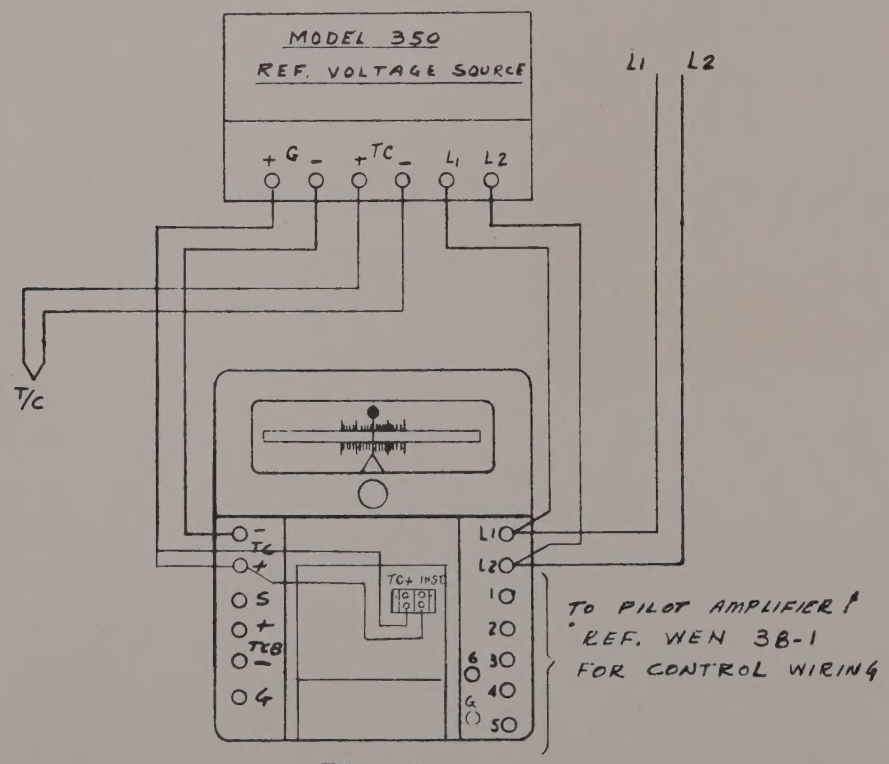


FIG. 3

Control

Refer to instruction book pertinent to control type used with Model 350 measuring system.

Measuring Circuit Specifications

Refer to block diagram Fig. 4. Basically, the system consists of three parts - the thermocouple or millivolt source, the M/350 reference voltage source and the galvanometer. The thermocouple or other source develops a potential by virtue of heat difference between the hot and cold junction. The potential produces a current determined by the total circuit resistance and the Model 350 reference voltage source setting. The Model 350 source generates a potential equivalent to the dial setting and contains circuit resistance. The galvanometer deflects proportional to circuit current, recognizes current polarity and contains circuit resistance.

BLOCK DIAGRAM SHOWING
MEASURING CIRCUIT COMPONENTS

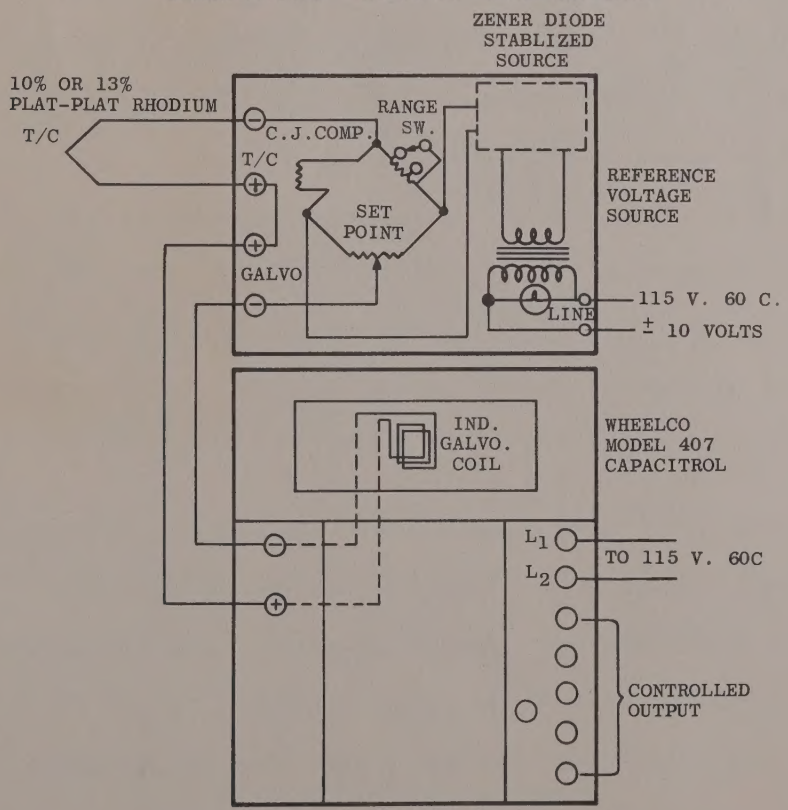


FIG. 4

The Model 350 reference voltage source is wired such that its polarity is bucking the thermocouple potential. The galvanometer is in series and recognizes the current which flows due to the unbalance between the T/C and RVS potentials.

$$\text{Galvo current} = \frac{\text{EMF}_{T/C} - \text{EMF}_{RVS}}{R_{T/C} + R_{RVS} + R_{Galvo} + R_{\text{lead wires}}}$$

When the current is zero, obviously the thermocouple output is equal the Model 350 output and the galvanometer indicates a null balance condition.

Calibration of Dial for Thermocouples

The dial controls the output potential value of the Model 350. The output is linear. When calibrated in degrees temperature and per thermocouple materials, the dial reading is not absolutely exact because thermocouples do not have linear potential output versus temperature. However, when small temperature spans are utilized the error is diminished. The Model 350 is calibrated so as to give a calibration approximating the curve and cutting the curve at two or more points. The error is thereby split being, a few degrees high at mid temp., and lower than indicated, approximately same value; at high and low end of calibrated range. This condition may be reversed, depending upon type of thermocouple and portion of range.

Fig. 5 shows a table of error due to T/C materials for various temperature spans. Ranges not within $\frac{1}{2}$ of 1 per cent of maximum range temperature are shaded areas and not recommended. Production tolerances are within an additional 1/5 of 1 per cent of span, if of same sign; or one per cent when of opposite sign.

Model 350 Range Table

	Theoretical Max Error at Mid Temp. Degrees Fahrenheit				
	13% Pt. Pl. Rh	10% Pt. 10Pt. Rh	C/A Type K	I/C Type J	Span °F
0-500	17	15.	- .5	3.2	500
500 -1000	4.6	3.4	1.5	.5	500
1000 -1500	3.5	2.8	-1.	4.6	500
1500 -2000	3.4	2.5	-2.5		500
2000 -2500	.4	.4	-3.8		500
2500 -3000	- .8	- .6			500
0-1000	35.	30.	5.	3.2	1000
1000 -2000	13.	11.	-7.4		1000
2000 -3000	- .52	- 1.			1000
500 1500	16.	12.	0	12.5	1000
1500 2500	8.	9.	-13.		1000
0-3000	113.	90.5			3000
0-2000	76.7	63.	-33.		2000
1000 3000	26.5	21.4			2000

Positive sign indicates actual temperature is lower than indicated, at extreme ends of range, and high same amount at mid point. Negative sign indicates actual temperature is higher than indicated at ends, etc.

FIG. 5

Calibration of Millivolt Dial

Millivolt calibrations down to 5 millivolts are standard and present no linearity problems. These are available in all suppressions to 500 millivolts. Linearity and hysteresis to 1/10 of one per cent. Accuracy to 1/5 of one per cent of span.

Galvanometer Scale Sensitivity or Equivalent Range

The deflection per degree or millivolt of the galvanometer pointer depends on the design of the galvanometer and circuit resistance of which galvanometer resistance is a portion.

To obtain maximum deflection per unit volt, the galvanometer must be designed with control springs of low torque and low resistance coil. A No. 15 spring with minimum coil resistance of 115 ohms; the sensitivity is approximately one inch deflection per millivolt, using zero multiplier resistance.

Because the galvanometer coil current (at unbalance) is a function of resistance, with constant potential difference, the value of thermocouple and lead resistance should be low as practical. The Model 350 value is especially designed to have an internal resistance of less than ten ohms. Considering these components, the equivalent temperature range can be calculated. Consider for example 2000 to 3000° F. 13% platinum rhodium thermocouple range: Galvanometer, #15 springs; Model 350 10 ohms, T/C and lead wire, 10 ohms, and series resistance 15 ohms.

From table below it is apparent that the instrument scale represents approximately ± 600° F each side of zero. With an external resistance of say 550 ohms with C/A type thermocouple, the scale would represent approximately ± 500° F each side of zero.

Temp. Span vs External Resistance * 400 Meter Movement with No. 15 Springs				
Span °F	Pt Rh	C/A	I/C	Span °C
200°			20Ω	111°
400°		100Ω	160Ω	222°
800°		320Ω	440Ω	444°
1200°	35Ω	510Ω	720Ω	666°
1600°	125Ω	765Ω		888°
2000°	165Ω	1000Ω		1111°
3000°	345Ω			1666°

* includes: T/C, lead res, M/350 and (series res. if used.)

Galvanometer Time Constant

When the Model 350 reference voltage source is used with a 400 Series control system, the dynamic response of the measuring system may be important.

The response of an overdamped galvanometer is essentially exponential and is in close approximation of first order system response. The sensitivity and time constant curve, Fig. 6, is accurate to approximately 10% considering variations in components and calculation assumptions. Stability and optimum performance is a compromise between overall gain and response. Short response time is generally advantageous. Increased gain is advantageous to a certain point, beyond this value, oscillation in controlled variable will result.

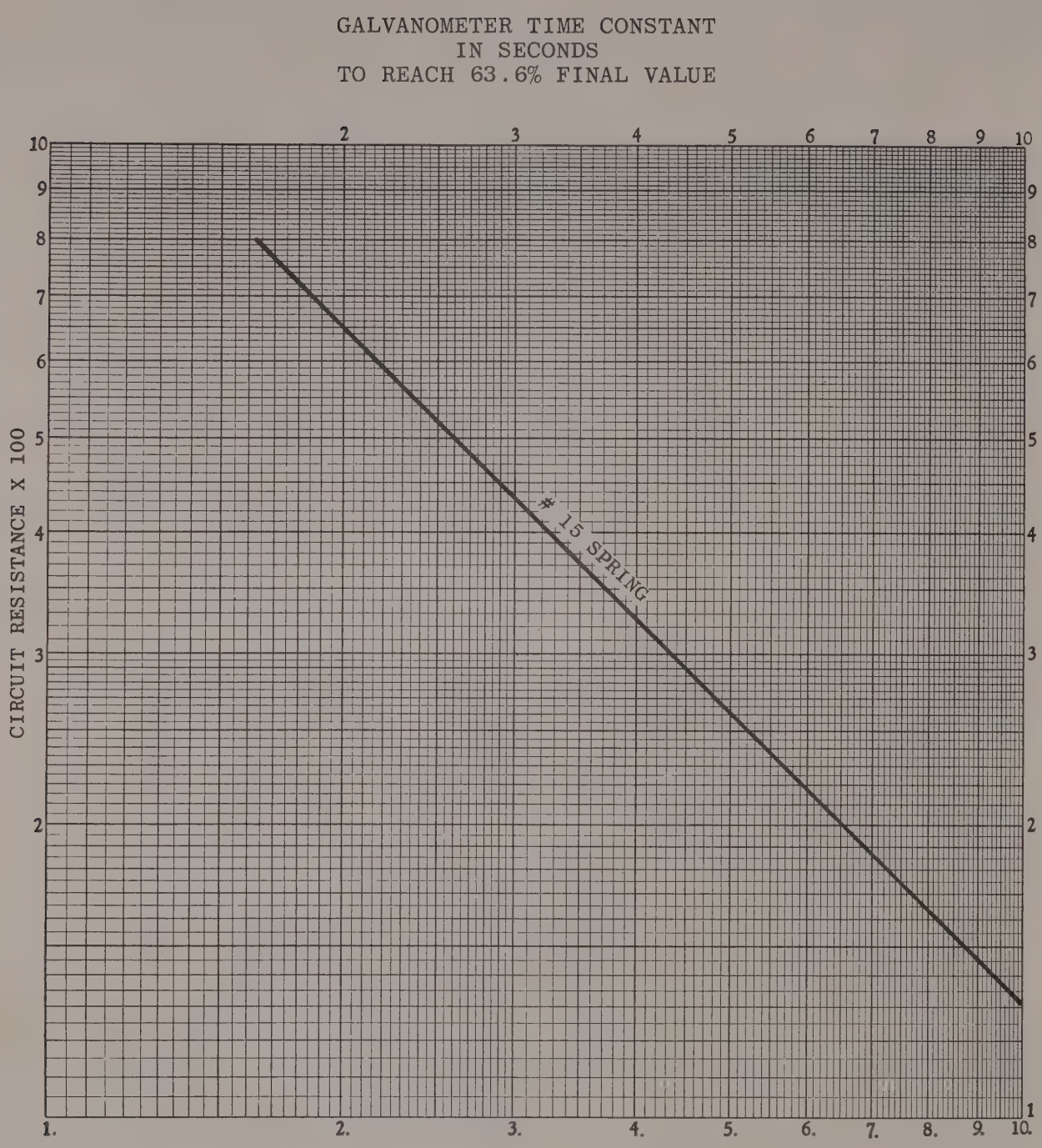


FIG. 6

Long time constant furnaces such as creep test will tolerate rather long time constant measurement with increased gain. This type application would best use No. 15 springs with low circuit resistance.

Short time constant processes best use No. 15 springs and add an amount of series resistance to decrease the time constant and gain.

The gain mentioned here is open loop gain and consists of all transfer units in system. This includes the measuring circuit, 400 control chassis, all pilot amplifiers, saturable reactors and transformers etc. The controller proportioning band adjustment is an adjustable gain control and provides convenient means of obtaining exact amount of overall open loop gain to insure stability with optimum response. The definition of proportioning band is percent of scale deflection to obtain 100% power range. This is convenient when considering a fixed scale instrument - it is not especially compatible when evaluating system open loop gain.

Tuning Instructions

Upon initial installation after connection to 400 Series instrument, power device and also power the 400 Series control chassis. Use an output device on chassis to determine control action. For instance, a 0-100 V DC meter when used with the 407 type controller. Use 5000 ohm load or appropriate pilot for the 407 chassis. When used with the Model 402, for instance, observation of relay action will suffice.

The object of tuning is to:

1. Obtain fail safe conditions.
2. Obtain null or near null conditions at control point.
3. Obtain zero T/C current at, or near, control point to eliminate line resistance effect.

For a heating process, adjust the mechanical zero of the galvanometer

one or two millimeters to right (or up scale) of null or zero point. Short "TC+" and "-" terminals on 400 housing left-hand terminal strip with screwdriver to decrease pointer swing. The mechanical zero adjustment screw is found on top of the 400 meter housing.

After mechanical zero adjustment, tune the appropriate 400 Series control chassis reset screw to obtain a near minimum (safe) power level into process at mechanical zero.

Recheck this condition after each proportional band and reset adjustment.

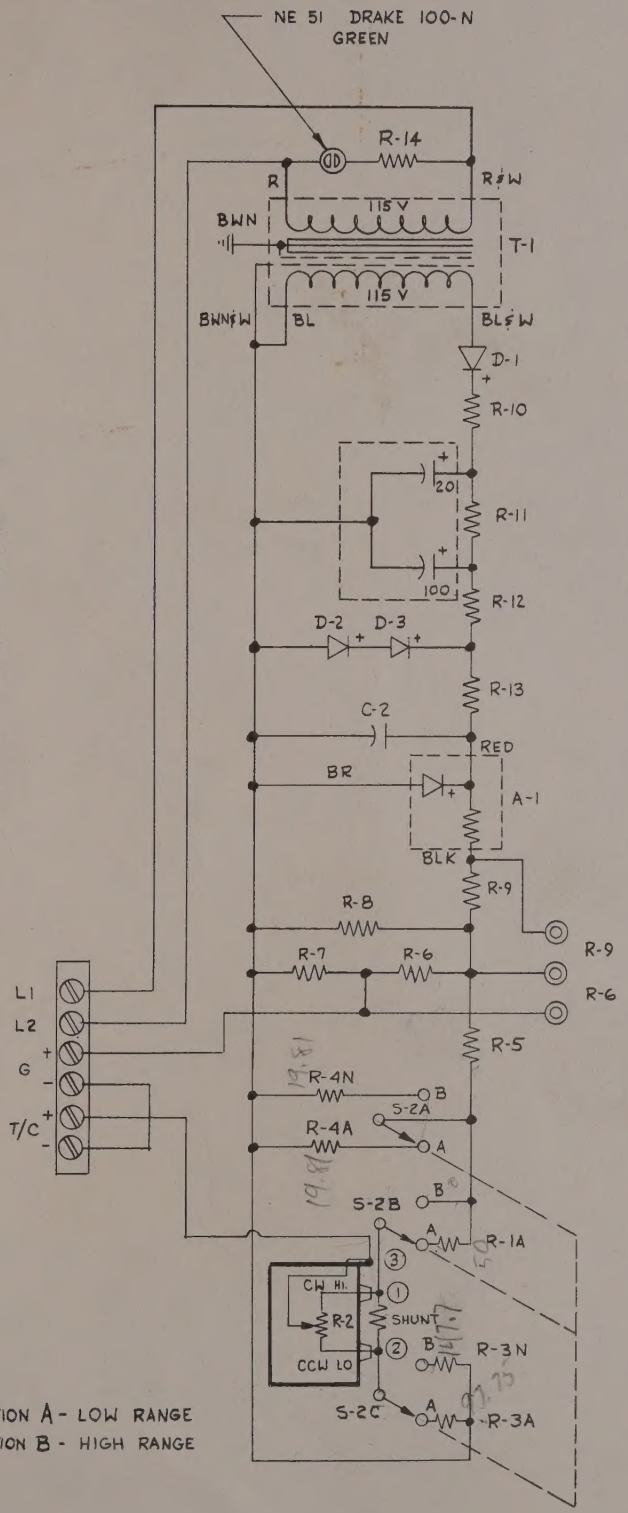
This adjustment insures minimum power level in case of thermocouple or lead wire break.

Model 350 Internal Circuit (Refer Fig. 7)

The reference voltage source contains a line voltage operated isolation transformer with rectifier section, followed by a Zenor diode voltage limiter. The source is stable to 3 micro-volts to a 10% line voltage change. A ten turn linear precision potentiometer is utilized as a voltage divider, with appropriate resistor network to suit specific ranges. A copper cold junction spool compensates for thermocouple cold junction calibration and is so located to sense immediate junction temperature conditions. The cold junction is at the T/C terminal posts, the internal of Model 350 and galvanometer being copper and soldered with low emf solder.

Ranges: The Model 350 is supplied in single, dual, or triple ranges consecutive, overlapping or isolated. We only recommend the ranges in Fig. 5 and equivalent centigrade ranges, though special scales are available.

MODEL 350 REFERENCE VOLTAGE
SUPPLY - DUAL RANGE



NOTE:
1. SWITCH POSITION A - LOW RANGE
2. SWITCH POSITION B - HIGH RANGE

ITEM	DESCRIPTION	PART NO.
A-1	POTTED RES. DIODE	A-3659
C-1	20-100 MFD	39-127
C-2	250 MMFD 500 V	39-076
D-1	65 MA RECT.	37-012
D-2	IN469	31-021
D-3	IN469	31-021
R-10	1000 Ω 1 W	CYZR171-10
R-11	3300 Ω 5 W	40-118
R-12	1000 Ω 1/2 W	CYZR171-7
R-13	470 Ω 1/2 W	CYZR170-32
R-14	22 K 1/2 W	CYZR170-1
S-2	3 P 4 POS SWITCH	CRL-PA1007
T-1	115V-115V TRANSFORMER	30-089-1

ITEM	PRECISION SPOOLS	MAT.
R-9	VOLTAGE CALIBRATION SPOOL	MN.
R-8		MN.
R-7	15.822 Ω	CU 80°F
R-6	FINAL CAL. SPOOL	MN.
R-5		MN.
R-2	100Ω POT., SHUNT TO 50	MN.
R-4A		MN.
R-4N		MN.
R-3A		MN.
R-3N		MN.
R-1A		MN.

FIG. 7

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